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INFLUENCE OF PROGRAMING TECHNIQUES AND OF VARYING LIMIT LOAD FACTORS ON MANEUVER LOAD FATIGUE TEST RESULTS*

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SUMMARY

Variable-amplitude axial-load fatigue tests were conducted on 7075-T6 aluminum-alloy edge-notched specimens having a theoretical elastic stress concentration factor of 4. The load programs were designed to approximate maneuver load spectra. Fatigue life was found to be shorter for random form tests than for block form tests having the same load spectrum. The greatest change in life occurred when the test program contained negative loads. Life for variable-amplitude tests was found to increase as much as 60 percent above the original test life after preloading with a program having a higher limit load factor. The summations of cycle ratios were approximately 2 for tests without negative loads but were approximately 1 for tests with negative loads.

INTRODUCTION

In recent years, the demand for increased performance of aircraft has accentuated the problem of fatigue failure. Failures in both commercial and military aircraft have necessitated costly programs of inspection and maintenance. In an attempt to reduce maintenance costs and the probability of accidents, aircraft companies have resorted to programed fatigue tests of structural components which are designed to simulate service conditions for the particular vehicle and component in question. Such testing is required primarily because there is no adequate theory for predicting fatigue life under variable-amplitude loading conditions.

Two frequently used methods of programing a variable-amplitude fatigue test are the block form program in which loads occur in small groups having identical amplitudes within each group and the random form test in which individual load cycles occur in random sequence.

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*The information presented herein was offered as a thesis, entitled "The Influence of Testing Techniques and of Varying Limit Load Factors on Maneuver Load Fatigue Test Results" by P. L. Corbin, in partial fulfillment of the requirements for the degree of Master of Science in Engineering Mechanics, Virginia Polytechnic Institute, Blacksburg, Virginia, October 1964.

Start

The difference in test results obtained by conducting a variable-amplitude fatigue test in random form rather than in block form has been evaluated for aircraft gust load histories (ref. 1). The present investigation has examined this effect for aircraft maneuver load histories in which almost all stress cycles are excursions above a positive 1 g stress rather than a mixture of cycles with positive and negative excursions as occur in a gust load history.

Three maneuver load histories were programed in both block and random form. Thus, it was possible to compare directly the results of tests with identical load statistics but differing in method of application. Another series of tests was conducted to evaluate the effect of placarding (restricting top speed and maneuver severity) an airplane.

The tests were conducted on sheet specimens of 7075-T6 aluminum alloy. Some of the results were analyzed and compared on the basis of Miner's linear cumulative damage theory; the other results were compared on the basis of total number of cycles.

→ 13

to p. 13

SYMBOLS

The units used for the physical quantities defined in this paper are given in both the U.S. Customary Units and the International System of Units (SI). Factors relating the two systems are given in reference 2.

K_t	theoretical elastic stress concentration factor
N	constant-amplitude fatigue life, cycles
n	number of cycles applied at a given stress level
r	notch radius, inches (centimeters)
S_i	stress at test level i, kips per square inch (meganewtons per meter^2)
S_{max}	maximum cyclic stress, kips per square inch (meganewtons per meter^2)
S_{min}	minimum cyclic stress, kips per square inch (meganewtons per meter^2)
S_{1g}	level flight stress, S_{min} for positive loads and S_{max} for negative load cycles, kips per square inch (meganewtons per meter^2)
η	service limit load factor, $\dfrac{\text{Maximum expected vertical acceleration}}{\text{Acceleration due to gravity}}$

LOAD DETERMINATION AND APPLICATION

Maneuver Load Statistics

The variable-amplitude fatigue tests were designed to approximate a maneuver load history. The frequency distribution of positive maneuver peak loads presented in reference 3 was converted to a spectrum of stress plotted against cumulative frequency. A 1 g stress $(S_{1\,g})$ equal to 7 ksi (48.3 MN/m^2) and a design limit load factor of 7.3 were assumed for this conversion. One set of maneuver peak load statistics from reference 3 is presented in table I. The converted data are presented graphically in figure 1. The lower curve in figure 1 is explained in a later section. This continuous load spectrum was reduced to eight discrete load levels using S-N data from constant-amplitude fatigue tests. The method used is described in reference 4 and the results obtained are presented in table II.

TABLE I

LOAD SPECTRUM STATISTICS

[Maneuver loads, reference 3]

Load factor	Number exceeding
7.3	13
7.0	23
6.0	115
5.0	430
4.0	1 220
3.0	2 800
2.0	5 600
1.0	10 000

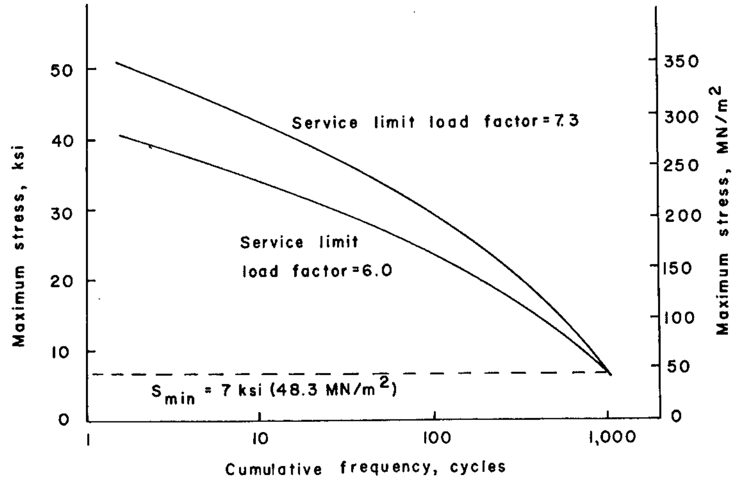

Figure 1.- Maneuver load cumulative frequency statistics.

Load Programing

The load statistics were programed in both block and random form with the same cumulative frequency spectrum. These two methods are described in the following paragraphs.

The block method of programing resulted in a variable-amplitude test with the loads applied in groups of identical cycles. Within each block each of eight amplitudes was represented one time and all of the cycles at that amplitude were applied before proceeding to the next amplitude. Within each block the sequence of load levels was varied according to a schedule taken from a table of random numbers. A different sequence was used for each block until the 20th block after which the schedule for the first 20 blocks was repeated.

TABLE II

VARIABLE-AMPLITUDE LOAD PROGRAMS FOR 7075-T6 ALUMINUM-ALLOY SPECIMENS USING MANEUVER LOAD HISTORY

[1 g stress = 7 ksi = 48.3 MN/m^2]

Step	Representative stress		n/step	n/N per step
	ksi	MN/m^2		
Program 1(a); design limit load factor, 7.3; block and random				
1	9.8	67.6	1 030	0
2	15.3	106	780	.0001
3	20.8	144	510	.0068
4	26.2	181	300	.0187
5	31.7	219	180	.0252
6	37.0	255	88	.0236
7	42.3	292	35	.0164
8	48.8	337	11.5	.0091
			2 934.5	0.0999
Program 1(b); block and random				
			Program 1(a) plus	
9	53.4	368	3.2	0.0038
10	58.6	404	.7	.0014
			2 938.4	0.1051
Program 1(c); block and random				
			Program 1(a) plus	
-1	-2.8	-19.3	15	0
-2	-9.8	67.6	1.5	0
			2 951	0.0999
Program 2; design limit load factor, 6.0; block				
1	7.8	54	1 030	0
2	12.2	84	780	0
3	16.6	115	510	.0037
4	21.0	145	300	.0038
5	25.4	175	180	.0094
6	29.6	204	88	.0092
7	33.8	233	35	.0072
8	39.0	269	11.5	.0037
			2 934.5	0.0370

The random method involved programing each load cycle independently. The sequence of cycles was determined by generating random numbers and assigning codes to various sized increments to shape the overall frequency distribution to match that from reference 3. The method of generating the random numbers and shaping the frequency distribution is given in reference 1.

TEST VARIATIONS

Automatic and Semiautomatic Tests

Since test results obtained on automatic machines in the present investigation were to be compared with results from tests conducted on semiautomatic machines, it was first necessary to determine whether machine effects would invalidate these comparisons. Therefore, the first test series consisted of a block form maneuver load program, program 1(a), conducted on both semiautomatic and fully automatic machines.

Block and Random Programs

The second series of tests was intended to determine whether significantly different results would be obtained from tests having the same load statistics but applied by different procedures. The following load programs were conducted in both block and random form:

Program 1(a) is shown in table II and was reported in reference 4 (load schedule 1). It was a block form maneuver load test with all stress cycles positive, a minimum load of 1 g, and a maximum load of 7.3g (design limit load).

Program 1(b) was the same as program 1(a) except that two additional stress levels were added above the highest level of program 1(a).

Program 1(c) was the same as program 1(a) except that two negative stress levels were added. Therefore, this program had eight positive and two negative stress levels.

Service Load Limits

Because of unforeseen design defects, vehicles frequently are placarded after relatively short service, this usually means that the maneuver severity and/or speed will be restricted to extend the fatigue life. This, in effect, reduces the service limit load factor η and it is therefore of interest to find in quantitative terms the effect of reducing η in a maneuver load test program.

In reference 4, block form fatigue tests were reported for $\eta = 7.3$ (program 1(a)). In program 2, the value of each stress cycle was reduced approximately 20 percent; this resulted in a program with $\eta \approx 6$. This program is referred to as the $\eta = 6$ program. The two programs were otherwise identical. The stress - cumulative frequency for both programs is given in table II and is shown in graphical form in figure 1.

Load programs 2(a), 2(b), and 2(c) were conducted in block form with load factors from program 1(a) for various percentages of the expected life at $\eta = 7.3$ and then completed with load factors from program 2. The following table shows the incremental values of program 1(a) used:

Program	Percent of expected life at $\eta = 7.3$ (program 1(a))	Percent of expected life at $\eta = 6$ (program 2)
1(a)	100	---------
2	---	100
2(a)	25	Remainder
2(b)	50	Remainder
2(c)	75	Remainder

The preceding test schedules were designed to evaluate the influence on fatigue life of reducing the service limit load factor. Frequently, the converse situation arises; that is, mission requirements cause the service limit load factor to be increased. In order to evaluate the effect of this type of change, load program 2(d) was developed. In program 2(d), loads were applied according to program 2 until approximately 50 percent of the expected life at $\eta = 6$ had elapsed, then the loads were increased to the values for program 1(a) for the remainder of the test.

TESTING MACHINES

A block diagram of the machine used in this investigation is shown in figure 2. The machine has a nominal capacity of ±10 000 pounds (±44.5 kN) in axial load and the system is capable of cycling rates up to 7 cycles per second (7 Hz) depending on the load range. Any one of 55 individually adjustable load controls is selected in an arbitrary sequence by a logic system which receives its signal from punched cards. Use of this electrohydraulic system allows the programing of any load history that can be represented by 55 or fewer discrete load levels.

In operation, the card reader transmits coded load information to a logic system. The logic system performs a series of functional checks and then switches the correct preset load control potentiometer into the sensing circuit. The voltage from the load control is combined with the output from a strain-gage bridge attached to a weighbar which is in series with the specimen. The resultant voltage (magnitude and polarity) is used to direct a servo valve. True load accuracy is estimated to be ±0.3 percent of full scale, or ±30 pounds (13.35 N). This system is explained in detail in reference 1.

SPECIMENS

The test specimens were made of 7075-T6 aluminum-alloy sheet, 0.090 inch (2.3 mm) thick. The specimen configuration is shown in figure 3 and consisted of edge notches with a theoretical elastic stress concentration factor of 4.0. The specimen fabrication procedures are given in the appendix. The material properties (from ref. 5) are given in table III.

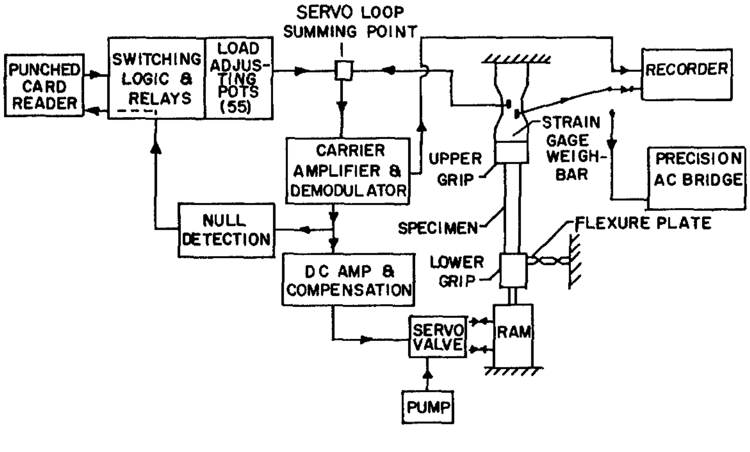

Figure 2.- Block diagram of programed variable-amplitude fatigue testing machine.

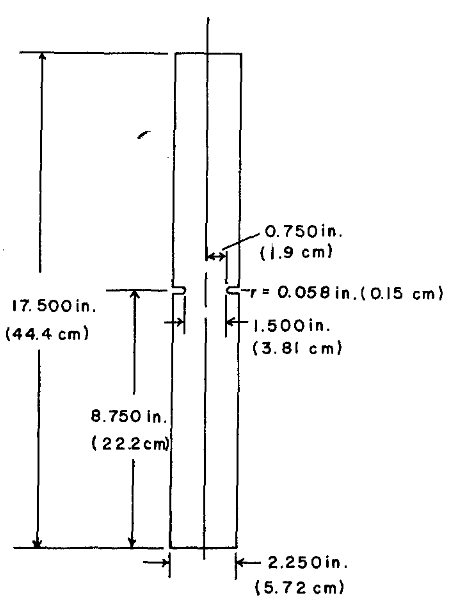

Figure 3.- Specimen configuration with edge notches made of 0.090-inch-thick (2.3 mm) 7075-T6 aluminum-alloy sheet. $K_t = 4.0$.

From p 13

TABLE III

Al

TENSILE MECHANICAL PROPERTIES OF 7075-T6 ALUMINUM ALLOY

[152 tests; data from reference 5]

	Ultimate tensile strength		Yield strength (offset 0.2 percent)		Total elongation in 2 in. (5 cm), percent
	ksi	MN/m²	ksi	MN/m²	
Average . . .	82.94	572	75.50	521	12.3
Minimum . . .	79.84	550	71.54	483	7.0
Maximum . . .	84.54	583	79.79	550	15.0

RESULTS

Test Data

The results of the variable-amplitude fatigue tests are presented in table IV and in figures 4 and 5. Data taken from reference 4 have been used to establish whether the variations investigated have an effect on fatigue life. For completeness, table IV contains the load step at failure and the specimen life (total cycles) in addition to life indices computed by Miner's linear cumulative damage theory. The scatter in the test results is not considered excessive and is indicated by the ticks on the symbols in figures 4 and 5.

Automatic and Semiautomatic Tests

A comparison of results from program 1(a), semiautomatic block and automatic block, showed no significant difference (table IV); therefore, it was concluded that any effects due to machine differences, load accuracy, speed differences, and so forth, were negligible.

Block and Random Tests

The results of the three sets of tests in the block and random series are shown in figure 4. The random test lives were invariably shorter than the block test lives but this effect was most pronounced for the program which contained negative loads. The random test lives for this particular program were about 40 percent shorter than the block test lives. This perturbing effect of negative loads was also noted for gust load tests in reference 1. Figure 4 also indicates that including negative loads in the test program has reduced specimen life by a factor of approximately 2 as compared with the same program without negative loads. This substantiates the findings of several investigations of this particular effect. (See, for example, ref. 1.)

TABLE IV

VARIABLE-AMPLITUDE TEST RESULTS MANEUVER LOAD SPECTRUM

Specimen	Load step at failure	n/N	Cycles
Program 1(a); block; semiautomatic; η = 7.3			
B52N1-4	8	2.34	69 911
B95N1-2	8	2.23	64 694
B51N1-2	8	2.04	59 815
B50N1-9	8	1.91	55 766
B56N1-1	8	1.85	54 083
B50N1-5	8	1.85	54 083
Geometric mean		2.02	59 440
Program 1(a); random; automatic			
B112N2-1	8	2.32	64 653
B84N2-1	8	2.17	64 413
B112N2-3	8	1.91	53 228
B105N1-7	8	1.89	52 672
B84N2-4	8	1.78	49 578
B84N2-7	8	1.69	47 065
Geometric mean		1.95	54 260
Program 1(a); block; automatic			
B85N2-6	8	2.41	72 748
B85N2-2	8	2.33	69 902
B84N2-2	8	2.33	69 902
B105N1-3	8	2.12	62 690
B85N2-4	8	2.03	59 805
B85N2-10	8	1.84	54 681
Geometric mean		2.17	64 500
Program 1(b) (program 1(a) + 2 levels > N_8); random			
B84N2-3	10	2.28	60 666
B85N2-7	10	1.74	46 300
B105N1-2	10	1.62	42 997
B85N2-9	10	1.44	38 221
B85N2-5	10	1.44	38 221
B84N2-3	10	1.44	38 221
B84N2-6	10	1.21	32 174
Geometric mean		1.47	42 200
Program 1(b); block*			
B49N1-5	10	2.80	79 069
B90N1-2	10	2.19	60 586
B96N1-1	10	2.19	60,586
B90N1-1	10	2.00	54 797
B90N1-5	10	1.67	46 978
B91N1-6	10	1.67	46 978
B94N1-2	10	1.67	46 978
Geometric mean		1.88	55 800
Program 1(c) (program 1(a) + 2 levels < 0); random			
B105N1-9	8	0.85	23 412
B85N2-3	8	.78	21 159
B85N2-1	8	.75	20 880
B105N-8	8	.75	20 706
B85N2-8	8	.74	20 357
B105N1-4	8	.63	17 393
Geometric mean		0.75	20 570

Specimen	Load step at failure	n/N	Cycles
Program 1(c); block			
B97N1-4	8	1.35	40 457
B104N1-2	8	1.26	35 705
B104N1-10	8	1.25	35 696
B96N1-3	8	1.10	32 466
B104N1-6	8	1.10	32 462
B97N1-7	7	1.01	29 511
Geometric mean		1.17	34 210
Program 2; block; η = 6			
B20N2-10	8	2.43	191 054
B2N2-2	8	2.35	184 430
B8N2-1	8	2.17	171 175
B6N2-10	8	2.08	162 804
B2N2-9	8	2.06	161 904
B4N2-2	8	2.04	160 191
B4N2-5	8	1.98	156 295
B19N2-9	8	1.88	147 705
Geometric mean		2.08	163 200
Program 2(a) (25 percent program 1(a) plus program 2)			
B8N2-3	7	3.61	285 454
B2N2-7	8	3.52	251 000
B3N2-2	8	3.23	228 760
B7N2-1	8	3.22	227 606
B2N2-8	8	3.06	215 564
B6N2-4	8	2.77	192 131
Geometric mean		3.22	227 599
Program 2(b) (50 percent program 1(a) plus program 2)			
B10N2-7	8	3.54	228 124
B7N2-5	8	3.36	214 201
B3N2-7	5	3.34	211 978
B6N2-5	8	2.74	164 878
B3N2-9	7	2.66	158 592
B6N2-9	6	2.57	152 298
Geometric mean		3.01	185 900
Program 2(c) (75 percent program 1(a) plus program 2)			
B7N2-4	8	3.38	191 360
B10N2-9	8	3.13	168 979
B5N2-5	7	2.74	140 207
B1N2-1	8	2.31	105 557
B4N2-3	7	2.17	95 579
B4N2-4	8	2.16	94,148
Geometric mean		2.61	127 600
Program 2(d) (50 percent program 1(a) plus program 2)			
B14N2-5	8	2.66	135 515
B15N2-5	8	2.26	115 572
B14N2-6	8	1.87	105 004
B15N2-1	7	1.82	103 568
B19N2-2	8	1.79	102 741
B19N2-3	8	1.70	100 347
Geometric mean		2.03	109 500

*Reference 4.

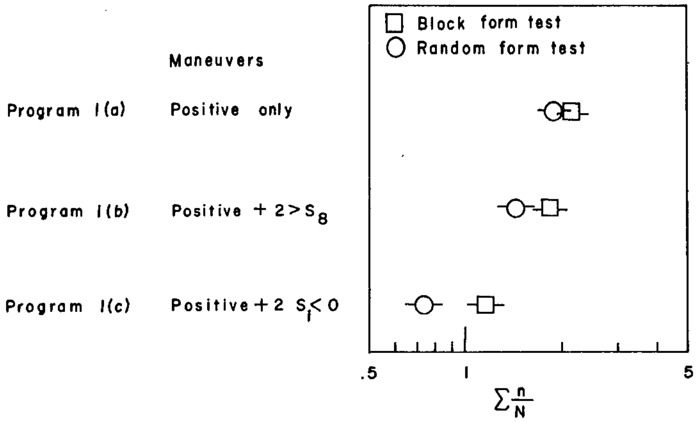

Figure 4.- Results of variable-amplitude fatigue tests showing effects of load randomization. Maneuver load spectrum; 7075-T6 aluminum alloy; 1g stress = 7 ksi (48.3 MN/m^2).

Tests With Varying Service Limit Load Factor

As shown in figure 5, the number of simulated flights the specimens survived first increased and then decreased as the prior history loading under the more severe program increased from 0 to 75 percent of the specimen's average life. For the particular combination of load factors and prior histories used, the life, in simulated flights, was a maximum at the 25-percent point, and the life under this combination was approximately 33 percent longer than the life under the less severe program by itself.

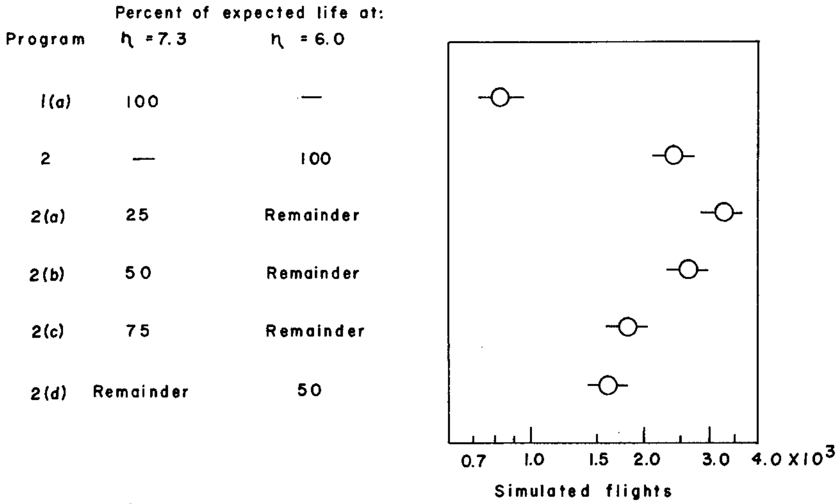

Figure 5.- Variable η test results. Maneuver load spectrum; 7075-T6 aluminum alloy.

Data Analysis

The results of the tests dealing with block and random programs were analyzed by Miner's theory. This theory is widely known and provides a convenient standard for comparison of fatigue test results. The tests concerned with changing load limits, however, were analyzed on the basis of the number of simulated flights the specimen survived. The number of simulated flights is equal to the number of cycles survived divided by 68, since from reference 3 the average number of cycles per flight was 68.

As an aid in judging whether an effect was present, the data were compared statistically with reference 6 as a guide. In order to make the statistical analysis, the distribution of test results was assumed to be log normal and a 95-percent confidence level was used. The standard deviations of the logarithms of test results were compared by the "F" test (i.e., sample standard deviations are (or are not) significantly different) and the means of the logarithms of test results were compared by the "t" test (i.e., sample means are (or are not) significantly different). The results of this statistical analysis are presented in table V. The values in table V provide quantitative support for the qualitative conclusions reached in the preceding observations.

TABLE V

RESULTS OF STATISTICAL ANALYSIS OF VARIABLE-AMPLITUDE FATIGUE TESTS

[Maneuver load spectrum; 7075-T6 aluminum-alloy specimens; 1 g stress = 7 ksi (48.3 MN/m^2)]

Side group \ Top group	Program 1(a), semiauto block	Program 1(a), automatic block	Program 1(a), random	Program 1(b), random (prog. 1(a) + 2 > S_8)	Program 1(b), block	Program 1(c), random (prog. 1(a) + $2S_1$ < 0)	Program 1(c), block
Program 1(a), semiauto block		No					
Program 1(a), automatic block	0.92		No				
Program 1(a), random		1.11		Yes	No	Yes	
Program 1(b), random (prog. 1(a) + 2 > S_8)			1.32		Yes		
Program 1(b), block			1.02	1.28		Yes	
Program 1(c), random (prog. 1(a) + $2S_1$ < 0)			2.60		2.52		Yes
Program 1(c), block						1.57	

	Yes
1.28	

Yes — Sample $\Sigma n/N$ geometric means are significantly different.

1.28 — Ratio $\Sigma n/N$ geometric means, $\frac{\text{Top group}}{\text{Side group}}$.

TABLE V.- Concluded

RESULTS OF STATISTICAL ANALYSIS OF VARIABLE-AMPLITUDE FATIGUE TESTS

[Maneuver load spectrum; 7075-T6 aluminum-alloy specimens; 1 g stress = 7 ksi (48.3 MN/m^2)]

Side group \ Top group	Program 1(a), block η = 7.3	Program 2 η = 6	Program 2(a) (25 percent prog. 1(a) + 2)	Program 2(b) (50 percent prog. 1(a) + 2)	Program 2(c) (75 percent prog. 1(a) + 2)	Program 2(d) (50 percent prog. 2 + 1(a))
Program 1(a), block η = 7.3		Yes	Yes	Yes	Yes	Yes
Program 2 η = 6	2.75		Yes	Yes	Yes	Yes
Program 2(a) (25 percent prog. 1(a) + 2)	3.82	1.39		No	Yes	Yes
Program 2(b) (50 percent prog. 1(a) + 2)	3.12	1.14	0.82		No	Yes
Program 2(c) (75 percent prog. 1(a) + 2)	2.14	0.78	0.56	0.69		No
Program 2(d) (50 percent prog. 2 + 1(a))	0.49	1.36	1.89	1.54	1.04	

	Yes
1.39	

Yes — Sample simulated flights geometric means are significantly different.

1.39 — Ratio simulated flights geometric means, $\frac{\text{Top group}}{\text{Side group}}$.

DISCUSSION OF RESULTS

Damage and Failure Considerations

Trends in fatigue life observed in the present tests are explained qualitatively on the basis of residual stress and residual static strength considerations.

Residual stresses.- Residual stresses are obtained whenever a local stress, such as at the root of a notch, has exceeded the elastic limit of the material. The plastically deformed material must be stressed to return to its original shape, and the necessary force is provided by the adjacent elastically strained material. Residual stresses cannot be computed accurately or determined by nondestructive testing; however, their effects can be determined through experimental methods and used to advantage.

Compressive residual stresses delay fatigue crack initiation and propagation, whereas tensile residual stresses have an adverse effect. The beneficial effects of compressive residual stresses will decay under repeated cycling, the rate of decay being determined by the relative magnitude of the highest load level and successive load levels.

Residual static strength.- Failure of the specimen occurs when the applied load equals the residual static strength of the specimen. The residual static strength of a specimen first decreases sometimes precipitously as a crack is initiated and then deteriorates further with increasing crack length. (See ref. 7.) In engineering materials, residual stresses probably have very little, if any, effect on the residual static strength. High loads which may produce residual stresses that increase fatigue life by retarding crack initiation and propagation may also cause early failure of a specimen containing a short fatigue crack if the load exceeds the residual static strength of the specimen. Table IV indicates that almost every specimen failed on the highest load in the program, which substantiates the above argument.

Block and Random Tests

In the block and random test series, program 1(c) showed the largest variation in life; this indicates that the presence of negative load cycles is one of the most disruptive factors in comparisons of block and random tests. This variation was probably due to the fact that in the block form test, the negative loads, which reduce beneficial residual stresses, occurred in groups at widely spaced intervals and in this form had little more effect than would single negative loads at like intervals. The same number of negative loads occurred in the random test, but in this case they were distributed throughout the test program and therefore, in effect, occurred at a much higher frequency. This multiplied their residual stress destroying capability and a correspondingly shorter life was obtained for the random test.

For test programs 1(a) and 1(b) the differences between lives of random and block tests were small. These differences were probably due to the fact that the random programs introduced more high load cycles in the interval of program used than was the case for the block tests. The random test schedules were programed to have the same statistics as the block tests for the total load history; however, the test life actually involved only a small interval of the complete history and the above situation was found to be true in the interval used.

It was noted that summation of cycle ratios were approximately 2 for the tests with all positive load factors, but were close to 1 for the tests containing negative loads. These results are consistent with the results published in reference 4.

Varying Service Limit Load Factor Tests

In test programs 2(a), 2(b), and 2(c) the lives were considerably longer than would be expected from linear damage accumulation theories. This increase in life may be explained on the basis of residual stresses; that is, the high residual stresses introduced by the large amplitude loads of the $\eta = 7.3$ level delayed crack initiation and/or growth at the subsequent lower stresses of the $\eta = 6$ level.

For program 2(d), in which the low stress levels preceded the high stress levels, the total life was approximately the sum of one-half the life at $\eta = 6$ and one-half the life at $\eta = 7.3$ which would be expected on the basis of linear damage theories. As noted, however, this concept does not hold for the other tests in which the high stresses preceded the low stress levels.

CONCLUDING REMARKS

Variable-amplitude axial-load fatigue tests of 7075-T6 aluminum-alloy sheet specimens were conducted according to loading schedules designed to approximate maneuver load histories. The results of these tests support the following observations:

Maneuver load fatigue lives were shorter for random form tests than for block-form tests having the same load spectrum. The shortest life occurred when the loads were applied in random sequence and negative loads were included.

Negative loads in a test program reduced fatigue lives by a factor of 2 as compared with the same test without negative loads. The corresponding summation of cycle ratios was found to be approximately 1 and 2, respectively.

Fatigue lives up to 60 percent above the original test life were obtained by preloading with a portion of a test program having a higher limit load factor.

All of the trends noted herein may be explained qualitatively with the aid of residual stress and residual static strength considerations.

to p. 15

Pg 7 ←

Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., August 5, 1965.

APPENDIX

Specimens

The material for specimens used in this investigation was taken from part of a stock of commercial grade 0.090-inch-thick (2.3 mm) sheets of 7075-T6 aluminum alloy retained at the Langley Research Center for fatigue test purposes. The material properties are given in table III. The material blank layout is given in figure 2 of reference 8.

Each specimen was stamped with a number identifying the specimen as to material, sheet number, and location within the sheet. For example, specimen B115N1-7 is 7075-T6 (B), taken from sheet 115, blank N1, seventh position.

The specimen dimensions are shown in figure 3. The specimen surface was left as received, and the longitudinal edges were machined and notched to give a theoretical elastic concentration factor of 4.0. This configuration was chosen because it has been found to have fatigue characteristics representative of aircraft components (ref. 9). The notch was formed by drilling a hole to form the notch root and then slotting to the specimen edge with a 3/32 inch (2.4 mm) milling tool. In order to minimize residual stresses due to machining, an undersize hole was drilled first and enlarged to the proper radius by using progressively larger drills. Drills were used to drill four specimen thicknesses and then replaced. The last three drill increments were 0.003 inch (0.076 mm) and a drill press with constant automatic feed was used.

Burrs left on the specimens by the machining process were removed by holding the specimen lightly against a rotating composition dowel impregnated with a fine grinding compound. This procedure was used to keep the present tests consistent with past tests conducted at the Langley Research Center. All specimens were inspected with a five power magnifying glass, and only those free of defects in and near the notches were used.

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